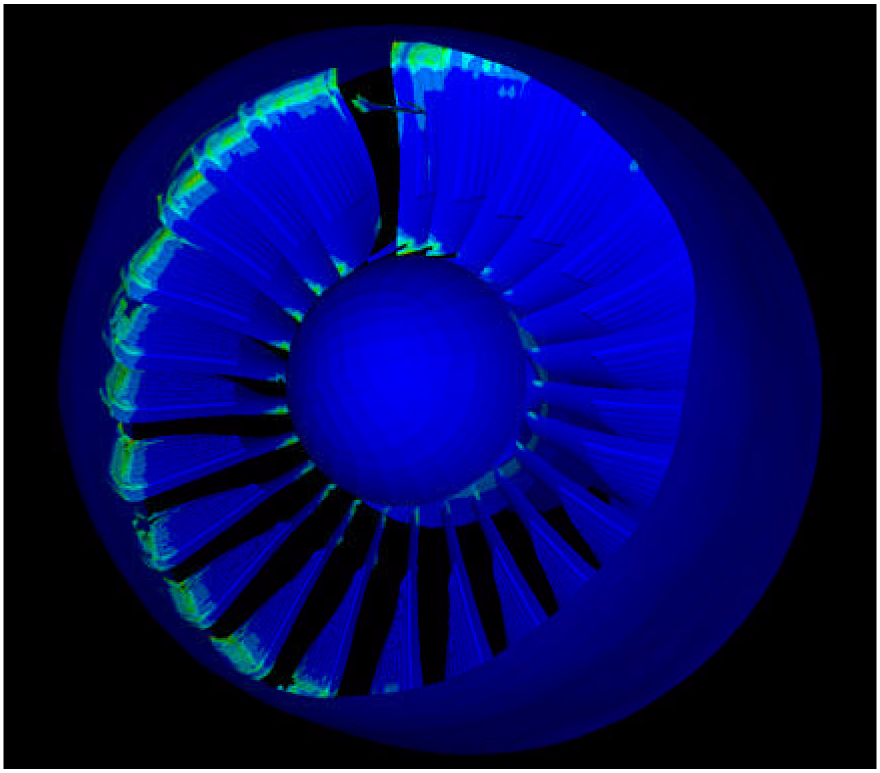
New Tools Being Developed for Engine-Airframe Blade-Out Structural Simulations



Detailed blade-fan case interaction model.

One of the primary concerns of aircraft structure designers is the accurate simulation of the blade-out event. This is required for the aircraft to pass Federal Aviation Administration (FAA) certification and to ensure that the aircraft is safe for operation. Typically, the most severe blade-out occurs when a first-stage fan blade in a high-bypass gas turbine engine is released. Structural loading results from both the impact of the blade onto the containment ring and the subsequent instantaneous unbalance of the rotating components. Reliable simulations of blade-out are required to ensure structural integrity during flight as well as to guarantee successful blade-out certification testing. The loads generated by these analyses are critical to the design teams for several components of the airplane structures including the engine, nacelle, strut, and wing, as well as the aircraft fuselage.

Currently, a collection of simulation tools is used for aircraft structural design. Detailed high-fidelity simulation tools are used to capture the structural loads resulting from blade loss, and then these loads are used as input into an overall system model that includes complete structural models of both the engines and the airframe. The detailed simulation (shown in the figure) includes the time-dependent trajectory of the lost blade and its interactions with the containment structure, and the system simulation includes the lost blade loadings and the interactions between the rotating turbomachinery and the remaining aircraft structural components. General-purpose finite element structural analysis codes are typically used, and special provisions are made to include transient effects from the blade loss and rotational effects resulting from the engine’s turbomachinery. To develop and validate these new tools with test data, the NASA Glenn Research Center has teamed with GE Aircraft Engines, Pratt & Whitney, Boeing Commercial Aircraft, Rolls-Royce, and MSC.Software.

Progress to date on this project includes expanding the general-purpose finite element code, NASTRAN, to perform rotordynamic analysis of complete engine-airframe systems. Capabilities that have been implemented into the code are frequency response (windmilling), complex modes (damped critical and whirl speeds), and static analysis (maneuver loads). Future plans include a nonlinear enhancement for blade-out simulation and construction of a test rig to determine blade-case interaction characteristics.

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